

31. (Added) The device as recited in claim 16, wherein said low-trap-density nitrogen-containing oxide and said high-K dielectric form a gate dielectric, wherein said gate dielectric has a low-trap-density.

32. (Added) The device as recited in claim 24, wherein said high-K dielectric has a low-trap-density.

33. (Added) The device as recited in claim 24, wherein said low-trap-density nitrogen-containing oxide and said high-K dielectric form a gate dielectric, wherein said gate dielectric has a low-trap-density.

REMARKS

Claims 30-33 have been added. Thus, claims 17-33 are pending in the case. Applicants hereby request further examination and reconsideration of the presently claimed application.

Section 103 Rejections:

Claims 16, 18, and 23 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,596,214 to Endo et al. (hereinafter "Endo") in view of U.S. Patent No. 5,972,751 to Ramsby et al (hereinafter "Ramsby"). Claims 17, 19, 21, and 22 were rejected under 35 U.S.C. § 103(a) as unpatentable over Endo further in view of U.S. Patent 6,015,739 to Gardner et al. (hereinafter "Gardner"). Claim 20 was rejected under 35 U.S.C. § 103(a) as unpatentable over Endo further in view of U.S. Patent 5,994,734 to Chou (hereinafter "Chou"). Claims 24-28 were rejected under 35 U.S.C. § 103(a) as unpatentable over Endo further in view of Ramsby and Gardner. Claim 29 was rejected under 35 U.S.C. § 103(a) as unpatentable over Endo further in view of Ramsby and Chou. These rejections are respectfully traversed as set forth in more detail below.

It is improper to combine references where the references teach away from their combination. *In re Grasselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983). Further, the proposed modification cannot render the prior art unsatisfactory for its intended purpose. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984) MPEP § 2143.01.

The cited art teaches away from a semiconductor device having a low-trap-density nitrogen-containing oxide arranged upon an upper surface of a semiconductor surface.

Independent claims 16 and 24 each recite in part, "a low-trap-density nitrogen-containing oxide arranged upon an upper surface of a semiconductor substrate." The cited art also teaches away from a thickness of less than 10 angstroms for the low-trap-density nitrogen-containing oxide; and a thickness of less than 10 angstroms for an overlying high-K dielectric. Independent claim 24 recites in part:

... wherein said low-trap-density nitrogen-containing oxide has a thickness of less than about 10 angstroms; a high-K dielectric ... arranged upon the nitrogen-containing oxide, wherein said high-K dielectric has a thickness of less than or equal to about 10 angstroms.

Rejected claims 17-23 and 25-29 depend from claims 16 and 24, respectively, and recite all their respective limitations.

The present Specification recites the desirability of low-trap-densities in the formation of devices having stable operating characteristics (Specification -- pg. 4, lines 8-18). Further, the Specification recites several methods that may lower trap densities. For example: "[t]he N₂O anneal is believed to reduce the trap density of the nitrogen-containing oxide" (Specification -- pg. 6, lines 16-17); "[t]he etch process [may be performed before annealing] ... in order to reduce the density of any traps which may be introduced ... during the etch process" (Specification -- pg. 6, line 29 - pg. 7, line 2); and "[t]hermal growth of nitrogen-containing oxide 12 is believed to provide a lower density of interface trap states" (Specification -- pg. 11, lines 27-28). Consequently, the Specification recites the desirability of low trap densities, and discloses several methods that may lower trap densities, and thereby form the presently claimed product (i.e., the claimed low-trap-density nitrogen-containing oxide).

Instead of describing a low-trap-density, Endo recites the need to increase the density of trap sites and further recites a method to increase the trap density (Endo -- col. 21, line 44 - col. 22, line 46). The non-volatile memory device taught by Endo appears to rely upon trap sites to operate correctly. (Endo -- col. 7, lines 14-20). Endo requires captured electrons for proper device operation. Therefore, Endo requires trap sites. For example:

The increase of the dielectric constant of the second dielectric film requires an increase of the number of the captured electrons at the trap centers provided that the thickness of the second dielectric film is kept constant. The increase of the number of electrons captured or trapped at the trap centers requires an increase of the number of interfacial trap centers on the interface between the first and second dielectric films. (Endo -- col. 14, lines 9-16, emphasis added.)

As such, Endo would be unsuitable for its intended purpose of maintaining captured electrons if modified to teach the claimed low-trap-density nitrogen-containing oxide. Further, Endo teaches use of low temperatures to maintain high trap densities (Endo -- col. 15, lines 13-19), yet the present Specification recites methods to reduce trap-densities that may involve the use of high temperatures (Specification -- pg. 13, lines 14-18); and (Specification -- pg. 6, lines 25-28). For at least these reasons, Endo teaches away from the presently claimed semiconductor device having a low-trap-density nitrogen-containing oxide arranged upon an upper surface of a semiconductor surface as claimed.

Further, Endo teaches away from the claimed thicknesses. For example, Endo recites "first dielectric film 3 having a thickness in the range of from 2.5 nanometers to 5 nanometers . . . second dielectric film 11 is formed on the first dielectric film 3 where a thickness thereof is ranged from 50 to 100 nanometers." (Endo -- col. 14, lines 54-66.) Endo repeats these ranges in column 7, lines 54-58, and in column 10, lines 4-10. Further, Endo teaches, "the minimum thickness of the first dielectric film would be 2.5 nanometers" (Endo -- col. 11, lines 3-5, emphasis added) and "50 nanometers in the thickness of the second dielectric film would be the minimum" (Endo -- col. 12, lines 14-17) (emphasis added). Thus, Endo teaches a minimum thickness of 25 angstroms and 500 angstroms for the first and second dielectric films, respectively. These minimum thicknesses are well above the claimed thicknesses of "less than about 10 angstroms" as recited by independent claim 24. Therefore, Endo also teaches away from the claimed thicknesses.

Applicants assert there can be no motivation to combine where the cited art teaches away from the claimed invention. Moreover, Ramsby does not and cannot remedy the deficiencies with respect to Endo such that the limitations (i.e., the claimed low-trap-density nitrogen-containing oxide layer) of independent claims 16 and 24 are met. According to the Office Action, Ramsby teaches nitrogen added to an oxide layer to produce a low trap density

layer, and therefore the nitrogen-containing oxide layer of Endo inherently has a low trap density (Office Action -- p. 2). This assertion is respectfully traversed. To rely upon the theory of inherency, the Examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art. *Ex parte Levy*, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990), MPEP 2112, emphasis in original. The Office Action, however, has not provided any evidence that Endo necessarily describes a low-trap density nitrogen-containing oxide as recited in claim 16. The Office Action has not and cannot provide any evidence that the oxide taught by Endo is a low-trap density nitrogen-containing oxide as claimed. Such evidence cannot be provided because, as noted above, Endo teaches away from such an oxide.

Similarly, Gardner does not and cannot remedy the deficiencies with respect to Endo and Ramsby such that the limitations (i.e., the claimed low-trap-density nitrogen-containing oxide layer, the claimed oxide thickness of less than 10 angstroms, and the claimed high-K dielectric thickness of less than 10 angstroms) of independent claim 24 are met. As noted above, Endo teaches minimum dielectric thicknesses that are well above the claimed thicknesses.

Endo cannot be properly combined with any art such that the limitations of the currently pending independent claims are met. Thus, the cited art cannot render the pending claims obvious. Therefore, independent claims 16 and 24, and claims dependent therefrom, are patentably distinct and in condition for allowance. Removal of the 103 rejections to claims 16-29 is therefore respectfully requested.

Further, it is asserted that some of the dependent claims are separately patentable. Claim 21 recites in part, "... said nitrogen-containing oxide has a thickness of less than about 10 angstroms." Claim 22 recites in part, "said silicon nitride has a thickness of less than or equal to about 10 angstroms." As noted above, Endo teaches minimum thicknesses that are significantly higher than these claimed thicknesses. Therefore, Endo does not and cannot teach or suggest the limitations recited by dependent claims 21 and 22. As such, claims 21 and 22 are separately patentable.

For at least the reasons cited above, the cited art does not and cannot teach or suggest all limitations of the aforesaid pending claims. Accordingly, removal of the § 103 rejection of claims 16-29 is respectfully requested.

Patentability of Added Claims:

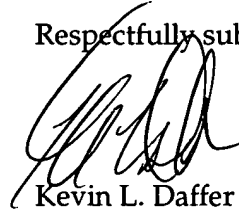
The present amendment adds claims 30-33. The limitations recited by the added claims can be found, for example, in the Specification, pg. 4, lines 16-18 and pg. 8, lines 8-13. In particular, "... the device is a transistor having a graded-K gate dielectric ... The graded-K dielectric is contemplated to have a low density of trap states." (Specification -- pg. 8, lines 8-13.) Therefore, claims 30-33 do not present new matter. Claims 30-33, which depend from either claim 16 or claim 24, are patentably distinct for at least the same reasons set forth above.

CONCLUSION

In the present response, Applicants have added claims 30-33 and responded to the rejections of claims 16-29. Accordingly, this response is submitted as a complete response to all issues raised in the Office Action dated May 9, 2001. In view of remarks traversing rejections, it is asserted that pending claims 16-33 are in condition for allowance. In addition, the cited art not relied upon does not appear to be pertinent to the patentability of the present claims. If the Examiner has any questions, comments, or suggestions, the undersigned attorney earnestly requests a telephone conference.

The Commissioner is authorized to charge any additional fees that may be required, or credit any overpayment, to Conley, Rose & Tayon, P.C. Deposit Account No. 50-1505/5500-36100.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Kevin L. Daffer', is written over the typed name.

Kevin L. Daffer

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Date: August 9, 2001

DSS

ATTACHMENT A
"Marked-Up Amendments"

IN THE CLAIMS:

Please add claims 30-33 as follows:

--30. (Added) The device as recited in claim 16, wherein said high-K dielectric has a low-trap-density.--

--31. (Added) The device as recited in claim 16, wherein said low-trap-density nitrogen-containing oxide and said high-K dielectric form a gate dielectric, wherein said gate dielectric has a low-trap-density.--

--32. (Added) The device as recited in claim 24, wherein said high-K dielectric has a low-trap-density.--

--33. (Added) The device as recited in claim 24, wherein said low-trap-density nitrogen-containing oxide and said high-K dielectric form a gate dielectric, wherein said gate dielectric has a low-trap-density.--